Human Mobility Patterns Generate Geographically Structured Sub-Epidemics in Namibia

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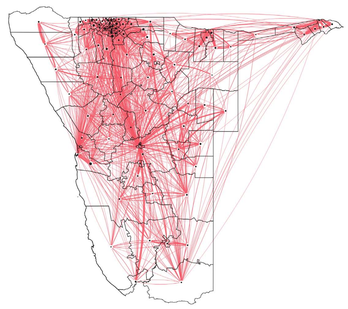
1. Background



www.nationsonline.org/oneworld/map/namibia-political-map.htm

Namibia has a severe, generalized HIV epidemic: prevalence is ~14%. The population is mobile: the average person spends 2.6 months outside their home community per year. A social/sexual community may therefore consist of several communities: we define this as megacommunity (MC). Our goal is to determine if MCs exist, and identify them.
We also characterize the demography and epidemics in MCs. We identify communities that have strong ties with MCs other than their own (bridges). MCs structure the HIV epidemic into loosely connected sub-epidemics.

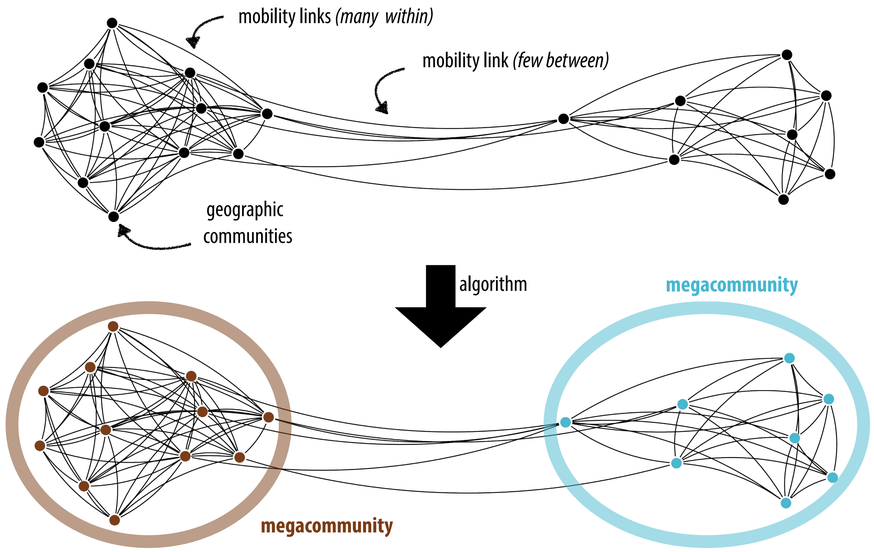
2. Data & Methods



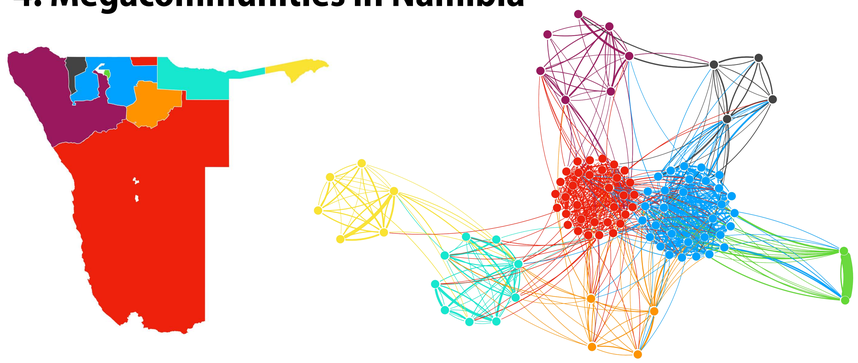
Nodes (black dots) represent the centroids of the constituencies. The thickness of a link (red line) represents the average fraction of time spent in one constituency by the residents of the other constituency over one year.

Mobile phone data collected in October 2010 - September 2011. Using 9 bn communications from 1.19 m SIM cards, network based on the average proportion of time residents spent in each of the constituencies in Namibia (constituency = geographic community). Population data from Census. HIV and demographic data from 2013 Namibian Demographic and Health Survey (NDHS). Community-detection algorithm infomap from mapequation.org and Rosvall, Bergstrom 2008 PNAS.

3. Megacommunities (MCs) as network modules

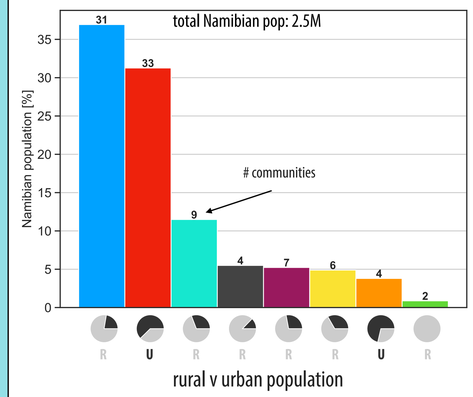


4. Megacommunities in Namibia



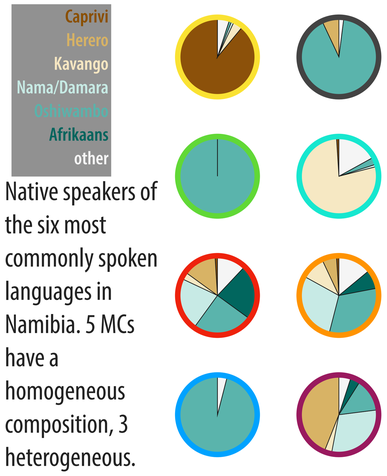
We find **8** MCs. In the network diagram each node is a constituency, and is colored according to the MC it belongs to. Node arrangement highlights the modular structure of the mobility networks. Links are colored according to the MC of destination.

5. Population of MCs



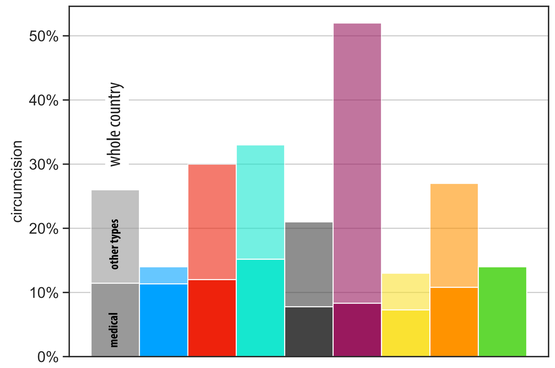
MCs have different sizes. The two largest contain together >65% of the Namibian population. They have different levels of urbanization. Two MCs have a population that is mostly urban, the other mostly rural.

6. Languages



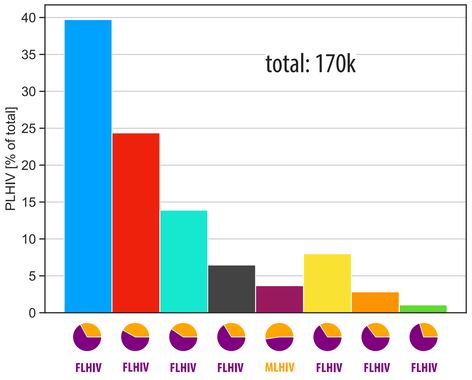
Native speakers of the six most commonly spoken languages in Namibia. 5 MCs have a homogeneous composition, 3 heterogeneous.

7. Circumcision



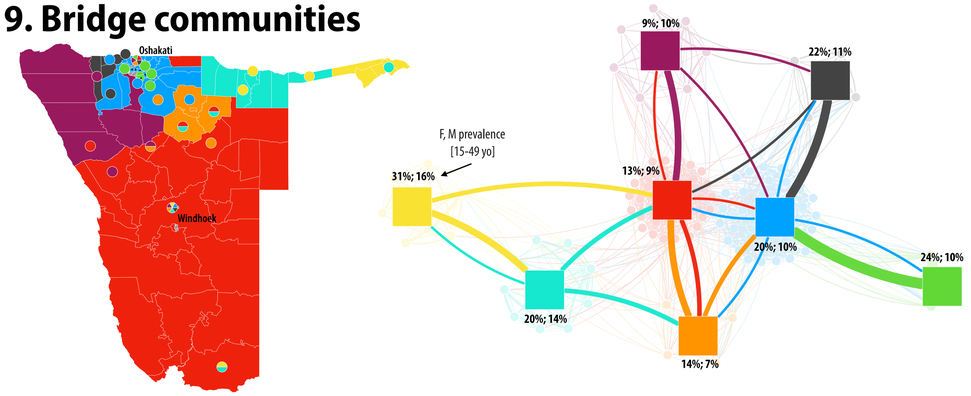
Prevalence of circumcision and medical circumcision. Blue MC: low circumcision, but mostly medical. Purple MC: high circumcision, but mostly non-medical.

8. People living with HIV



PLHIV (15-49 y.o.) heterogeneously distributed among the MCs (and heterogeneous prevalence).Women-to-men ratio of PLHIV also heterogeneous.

9. Bridge communities



A community is a **bridge** if it has significant mobility ties with communities outside its own MC. E.g., a community in the red MC is a purple bridge if a lot of people living in the purple MC spend time there. Bridge communities are indicated by circles colored with the MC they are bridging. The network shows bridge-mediated mobility links among MCs.

10. Conclusions

- **Mobility** divides Namibia into **8** social/sexual communities: **megacommunities**.
- **MCs** structure Namibia's epidemic into **sub-epidemics**.
- **MCs** provide insights into the most effective way to implement **interventions**, e.g., language-specific, circumcision.
- **Bridges** might be **gateways** for strain **importation**.

Acknowledgements

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